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ALASKAN GLACIERS IN RELATION TO LIFE

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(Map facing p. 818.)

Introduction. In this paper some of the geographical aspects of the present and the former Alaskan glaciers are briefly presented, including their functions (a) as barriers to communication, (b) highways for natives, prospectors, geologists, and mountain climbers, (c) barriers to railroads, (d) sources of ice supply, (e) sources of water supply for mining, (f) in relation to placer gold, (g) as obstacles to coal and copper mining and transportation, (h) controls of plant and animal life, (i) modifiers of climate, (j) causes of unnavigable streams and producers of water power, (k) effects in modifying lake and fiord highways, and (l) in making or destroying harbors and town sites.

This paper is based, in part, upon field work in Alaska for the U. S. Geological Survey in 1904, for the American Geographical Society of New York in 1905, and for the National Geographic Society of Washington in 1909, 1910, and 1911; but largely upon the published accounts of the men whose splendid pioneer journeys are here mentioned.

Glaciers as Barriers to Communication. A mountain and glacier barrier extends along the Alaskan coast (Fig. 1). On the seaward side of the lofty Pacific ranges, the ocean winds cause heavy precipitation, the mountains have heavy snowfall (Fig. 2) and glaciers fill the passes. In spite of low passes, therefore, the mountain barrier is one of the most effective in the world, and it partly isolates the interior of Alaska, which contains mineral wealth that people have eagerly tried to reach.

There are three feasible routes to the interior of Alaska. That by the White Pass and upper Yukon is not only difficult, but has

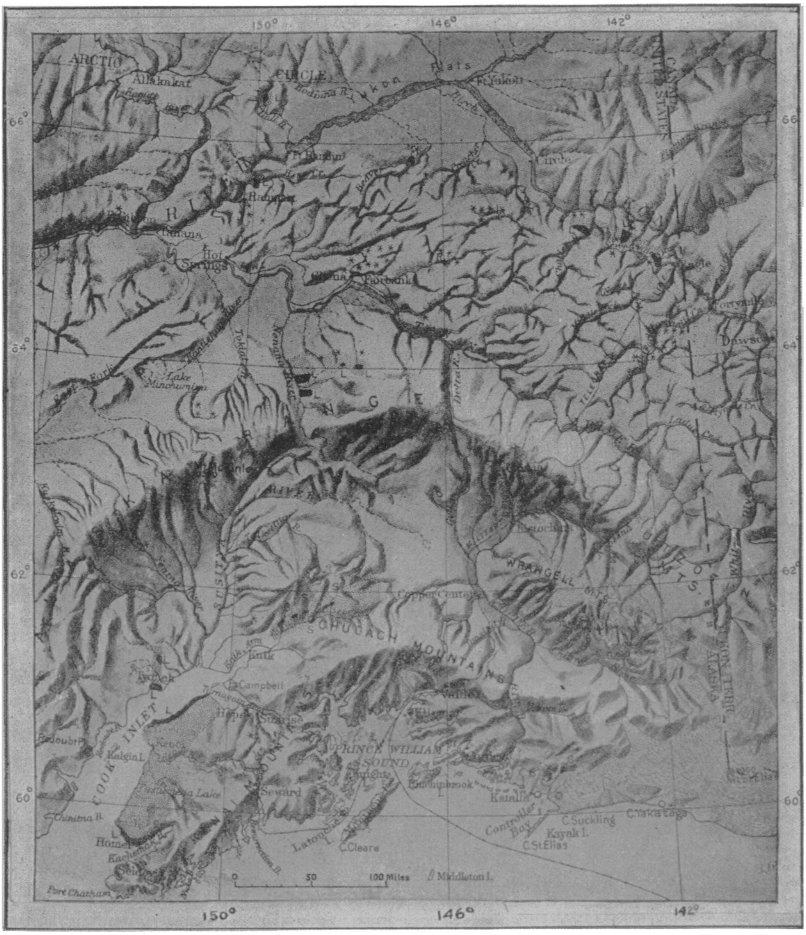

Fig. 1—Part of the coast of Alaska, showing the mountain barriers. (After U. S. Geological Survey.)

the disadvantage of leading partly through Canada. That by the Lower Yukon is roundabout and closed part of the year by ice. The third includes several routes which lead directly across the mountain barrier by one or another of the passes. In their efforts to get across the passes men have utilized the glacier highways, the most suitable for travel being the through glaciers; but here, as in other lofty mountain regions, those glaciers which head in cirques or in high mountain valleys are barriers to travel.

Early Glacier Highways.[1] How much glaciers were used as highways by Alaskan aborigines is not known. The natives seem to dread the ice, no doubt because of unhappy experiences upon it. Nevertheless they have traveled across the glaciers when necessary, for example, across part of Muir Glacier from Glacier Bay to Lynn Canal, across the glaciers of the Fairweather Range from the Pacific Coast near Lituya Bay to Glacier Bay, over a glacier northeast of Chilkat Pass, over glaciers in southeastern Alaska near Taku Inlet, and southeast of Sumdum and over a portion of Bering Glacier. There are also rumors of glacier travel by the natives in the region between Yakutat Bay and the Alsek River and from Prince William Sound to the Copper River valley.

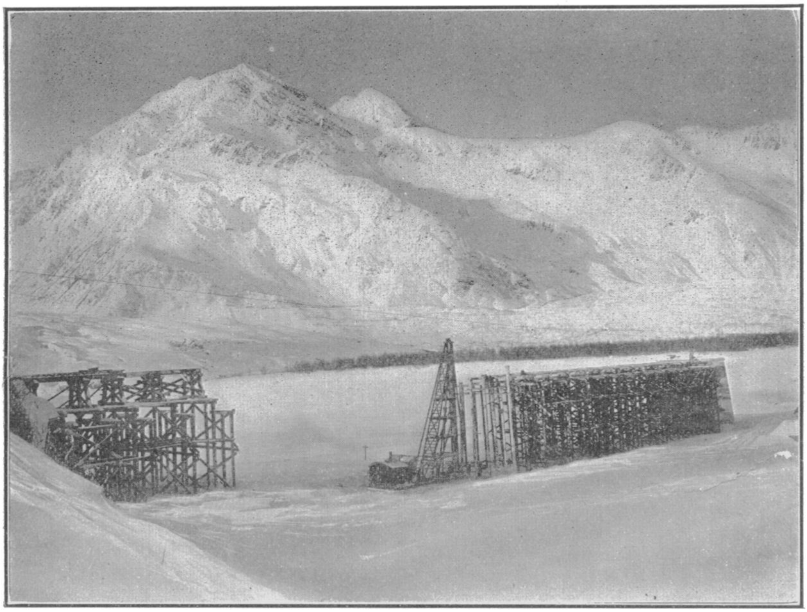

FIG. 2—The heavy snowfall on the coast ranges of Alaska. View near Childs Glacier.

The Russians seem also to have traveled over the ice, for Captain Abercrombie, U. S. A., in 1884, and the prospectors who reached the head of Port Valdez in 1898 heard rumors of a Russian route over the ice to the Copper River in the middle of the last century. In 1880 Petroff went across the Portage Glacier, from Passage Canal in Prince William Sound to Turnagain Arm of Cook Inlet.

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[1] Glacier Highways in Alaska were described by the author before the Association of American Geographers, Chicago, December, 1907.

Glaciers as Highways for Mountain Climbers. The use of Alaskan glaciers as highways by mountain climbers begins with the attempts to ascend Mt. St. Elias. The Malaspina and some of its tributaries were thus utilized by Schwatka, Libbey, and Seton Karr in 1886, by the Tophams and Broke in 1888, by Russell in 1890 and 1891, and by Bryant and the Duke of the Abruzzi in 1897. Glaciers and snowfields in the St. Elias Range and the Canadian Coast Range were also traversed in the repeated series of daring ascents by Brabazon, Mosheim, and other Canadian boundary surveyors in 1894-5 and by Morse, Riggs, Netland, Martin, Eaton, Ogilvie, Baldwin, and other American and Canadian surveyors who have been locating the Alaskan boundary between 1906 and 1913. Dunn, Parker, Cook, Stuck, and others have climbed upon glaciers and snowfields of Mt. Wrangell and in the Alaska Range near Mt. McKinley. The early failures to reach the top of Mt. McKinley and the many attempts necessary before St. Elias was finally ascended are due especially to the glacial conditions. In 1911 and 1912 Miss Dora Keene traversed the Kennicott Glacier in her ascent of Mt. Blackburn.

Glaciers Traversed by Geologists. Early traverses upon glaciers in Alaska were made by Hayes and Schwatka in 1891 northwest of the St. Elias Range, by Schrader in 1898 across Valdez Glacier and by Mendenhall the same year across the Portage Glacier, by Rohn in 1899 across the Wrangell Mountains,—one of the most daring glacier trips during the exploration of Alaska,—and by Brooks, Spurr, Spencer, Gerdine, Witherspoon, Moffit, Capps, and others in various parts of Alaska. These men were not climbing mountains, as was the geologist, Russell, but were necessarily utilizing glacier routes, upon which they happened while engaged in their geological and topographical work. Some of the army officers utilized glacier routes in much the same way.

Prospectors Stampeding Across the Glaciers. The story of the stampede of American prospectors to the port of Valdez and of their travels across Valdez Glacier has been told before, notably by the geologist Schrader, and by the army officers Abercrombie and his lieutenants, who traversed the Valdez Glacier at the same time. No such wholesale travel across a glacier highway has ever been recorded. It is not remarkable that a barrier[2] such as the Valdez Glacier (Fig. 3) interposes in this pass should have been overcome, for the glacier route is only 24 miles long and the pass but 4,800 feet high. The remarkable fact is that men should have succeeded in packing great outfits of provisions and equipment over this route and have taken horses and mules over the glacier, and that in a single season 3,000 or 4,000 men should have been able to reach the interior of Alaska by this route. Many prospectors, mainly unskilled in glacier travel, stormed this glacier-filled pass and conquered it, passing on with their provisions and other impedimenta. They straggled back in disorder, defeated not by the glacier but by the lack of gold and by disease and starvation which overtook them in the open valleys beyond the mountain barrier.

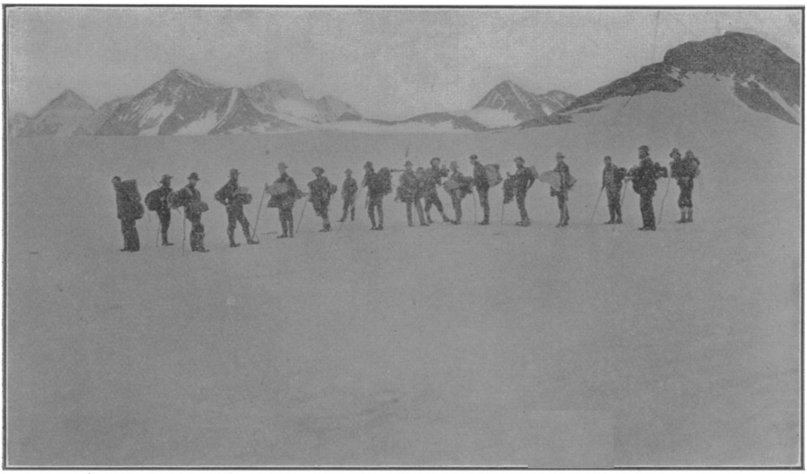

Fig. 3—Prospectors on the summit of the Valdez-Klutena through glacier in 1898.

East of Yakutat other glaciers were assailed in the attempt to reach the interior of Alaska. As the lower Alsek River, like the lower Copper, is blocked by glaciers, the most inviting route led by way of Yakutat Bay and Russell Fiord, thence eastward over the through glaciers to an upper part of the Alsek River. The glacier route was harder than that at Valdez, being 40 miles or more in length, but the passes were only 3,000 or 4,000 feet high. There were many more glacial routes here than in the Valdez region, but only 300 or 400 prospectors went over them in 1898. The chief routes were across the Nunatak and Fourth Glaciers from Russell Fiord; but Yakutat Glacier was also traversed. Boats, sledges, stoves, etc., were abandoned where these men left the ice (Fig. 4), and some of them have been found by the writer on his visits to the Yakutat Bay region. The route over Fourth Glacier is said to be still utilized occasionally by prospectors.

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[2] Martin, L.: Mastering the Alaskan Glacier Barriers, *Scientific American Supplement*, Vol. LXXI, 1911, pp. 305-307; Crossing the Alaskan Glaciers, *Collier's Weekly*, Vol. XLVII, 1911, No. 17, p. 20.

Glaciers as Barriers to Railroads. Railroad routes are even more subject to geographical control than the simpler highways described above; and, as has been shown by Brooks,[3] the mountains near the coast are serious barriers to railroad building in Alaska. But the great glaciers within these coastal mountains have been even more important as barriers to railroad building, particularly along the lower Alsek and the lower Copper Rivers. In the latter locality, however, where the Miles, Childs, and Allen Glaciers interpose obstacles to river navigation and travel, a railroad has been built in the last few years that is overcoming the difficulties interposed by the ice tongues and providing what may prove to be a permanent highway to the interior of Alaska.

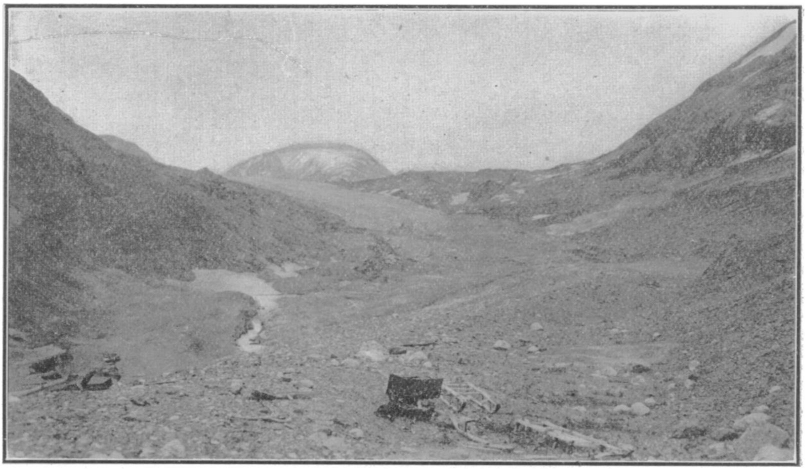

Fig. 4—End of the Nunatak Glacier highway, showing sleds, snowshoes, boats, a stove and other abandoned impedimenta.

As the map (Fig. 5) shows, there are many difficulties encountered in railroad building past these glaciers. It was necessary to provide a terminal some distance west of the mouth of Copper River (Fig. 12), whose delta is so shallowed by glacial deposition that ocean-going vessels cannot land there. A deep harbor was sought, accessible to steamships and also protected from ocean winds and waves. This was in southeastern Prince William Sound, where the terminus of the railroad was located, and the town of Cordova has been built.

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[3] Brooks, A. H.: *U. S. Geol. Surv. Bull. 284*, 1906, pp. 10–17; *Natl. Geogr. Mag.*, Vol. 18, 1907, pp. 165–186; *U. S. Geol. Surv. Bull. 520*, 1912, pp. 45–88.

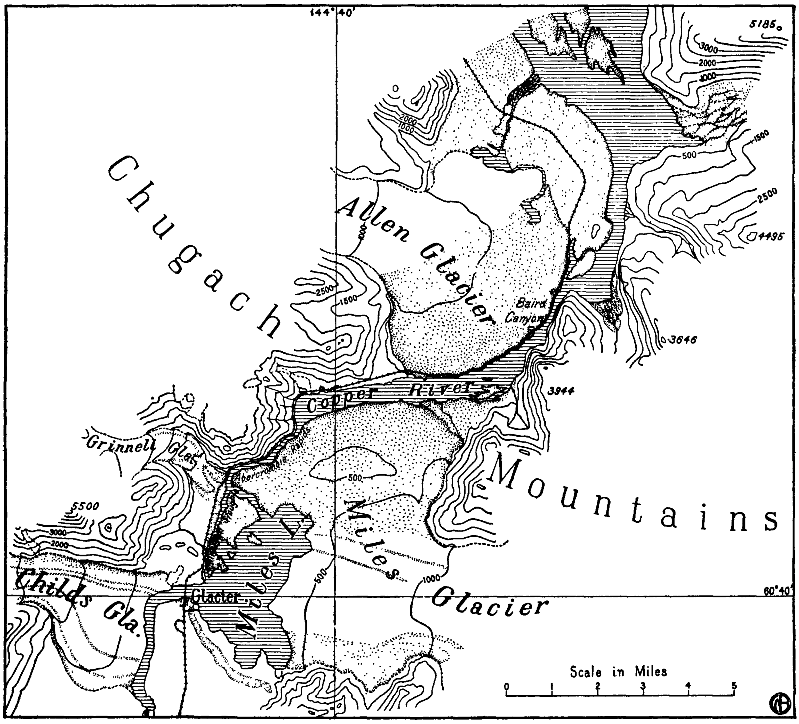

FIG. 5—Map of Miles, Childs and Allen Glaciers in the Copper River canyon, showing the Abercrombie and Baird Canyon Rapids which are caused by constriction of the Copper River by the glaciers.

The railroad runs eastward across the great delta of the Copper River, which coalesces with that built by streams from the Sheridan, Scott, Martin River, and adjacent glaciers. On this part of the route shifting glacial streams made railroad building difficult, and where the rails cross the main Copper River to the east bank two great bridges were necessary. They are respectively 3,350 and 4,000 feet in length and have 1,350 and 600 feet of steel spans.

Their erection and maintenance are hampered by the glacial origin of the river crossed, which is subject to great and rapid fluctuations of volume and load, so that quicksand bottom, erosion, deposition, shifting of channels, and floating ice all added to the problems of the bridge engineers.

The projecting of Miles and Childs Glaciers from tributary valleys nearly opposite each other (Fig. 5) made necessary a second crossing of the river between these two glaciers. Here the river is united in one stream, which is deep and swift, and the steel bridge is 1,550 feet long. The three steel bridges up to this point cost over $4,000,000. Before the bridge was completed a car ferry (Fig. 6) was used to take locomotives, cars, and supplies to the section of the railroad above this bridge. The glacial conditions favored this, for the constriction of the Copper River by Childs Glacier, which gives rise to the lake in which Miles Glacier terminates, causes relatively slack water in the river above the Childs Glacier rapids. Ferryboat traffic was, therefore, much easier than if a swift current had to be crossed.

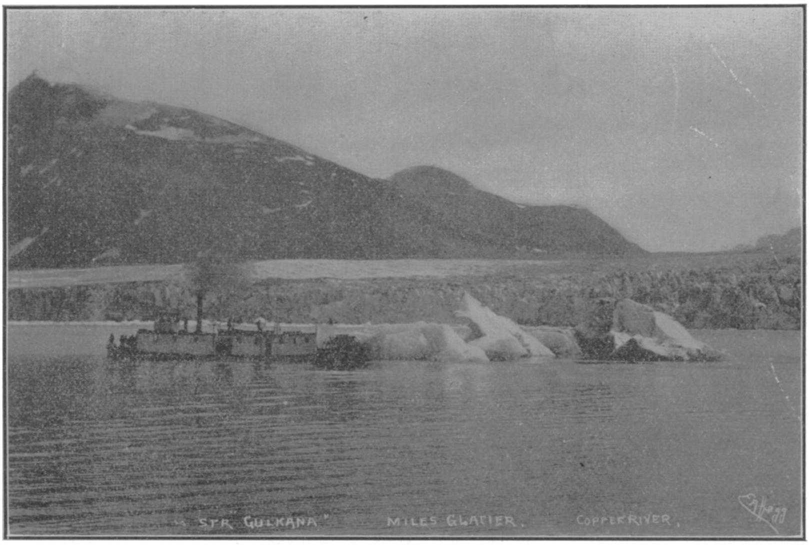

FIG. 6—Ferryboat on lake near Miles Glacier in 1909.

Sometimes a glacier advances and threatens a railroad, as Childs Glacier did in 1910,[4] and as Allen Glacier began to do in 1912.

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[4] Martin, L.: The National Geographic Society Researches in Alaska, *Natl. Geogr. Mag.*, Vol. 22, 1911, pp. 541-548; Gletscheruntersuchungen längs der Küste von Alaska, *Pet. Mitt.*, Vol. 58, 1912, Aug., pp. 79-81.

Where the expanded bulb of Miles Glacier, now stagnant, long ago pushed the Copper River over into Abercrombie Rapids,—a marginal channel cut in the rock along the mountain side,—the railroad building was made slow and expensive. The glacier occupies the whole valley, and the river sweeps the base of the mountains, so that it was necessary to blast out a shelf on the mountain side on which to lay the tracks. The dangers of rock avalanches and snow slides were forced upon the railroad engineers by the glacial conditions in the valley below. From Cordova to this point, 55 miles, the railroad construction cost over $5,700,000 in addition to the cost of some of the bridges. The whole 200 miles of railroad from Cordova to the Bonanza copper mine cost over $20,000,000, of which the steel bridges across glacial streams and the rock work caused by glacial conditions made up a large part.

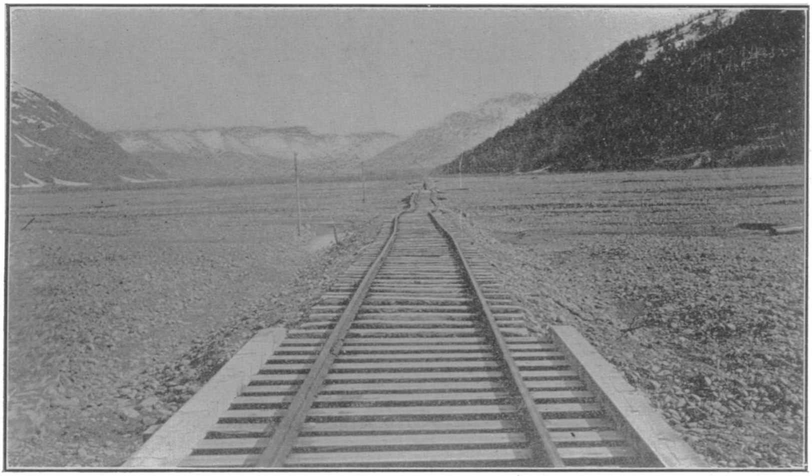

Fig. 7—Alaskan Northern R.R. upon the outwash plain of Spencer Glacier. The bridge in the foreground has been filled 6 or 8 feet with the gravels, which also cause the curves in the formerly straight track.

Above Abercrombie Rapids the railroad builders faced another dilemma, for here Allen Glacier (Fig. 5) projects from the west clear across the main valley, forcing the river into the Baird Canyon rapids. They decided to build the railroad on the glacier itself and so blasted out a grade across $5\frac{1}{2}$ miles of the stagnant, moraine-veneered, tree-covered ice mass.[4a] Ice lies beneath the ties and rails and future melting will cause slumping and repeated grading. Advance of the glacier will introduce still further difficulties.

[4a] Martin, L.: Un chemin de fer sur glacier dans l'Alaska, *La Nature*, Vol. 41, 1913, pp. 404–407.

Above Allen Glacier the glacial complications of railroad building seem, now at least, to be of less moment, though glacial streams furnish difficulties and promise permanent expense in upkeep and operation. A slight advance of Kennicott Glacier would destroy the terminus of the railroad and the mine bunkers there.

Other railroads in Alaska have not had similar difficulties. Doubtless glacial erosion of hanging valleys and over-steepening of valley walls added to the expense of building the White Pass and Yukon R.R. above Skagway, though former glacial erosion may have lowered the pass. The Alaska Northern R. R., terminating at Seward, traverses glaciated valleys, but has thus far encountered no trouble from ice tongues. In 1910 this railroad had great difficulty, however, with outwash gravels (Fig. 7) from Spencer Glacier.[5] The construction of the salmon railroad of the Yakutat and Southern R. R. was made easier by the smooth, glacial outwash plain of Yakutat Foreland, over which a large part of its track runs.

Sources of Ice Supply. In Port Valdez, Prince William Sound, the United States army troops at Fort Liscum secure their ice supply for refrigeration (quite as necessary in the mild summer climate of Alaska as in the United States) by sending detachments of soldiers 10 miles down the fiord to Shoup Glacier, where icebergs are gathered upon a lighter and towed by the launch to the fort.

If this glacier continues retreating and ceases to be tidal, this supply will be cut off, unless an ice quarry is opened in the glacier.

In southeastern Alaska the glaciers have also been a source of ice supply. Dall[6] relates that a ship took a load of ice for California in the winter of 1853-4 from either LeConte or Baird Glacier. Ice for San Francisco had previously been brought around Cape Horn from Boston, and a company supplied lake ice from freshwater ponds near Sitka and Kodiak between 1852 and 1863. Glacier ice does not seem to have been used except in this one locality. The price varied between $7, $25, $35, and $75 a ton, and one cargo of 250 tons of glacier ice was sold for $18,000. Today the quarrying of ice from non-tidal glaciers might not be profitable, but ice supply gathered from floating icebergs on the Copper River for use at Cordova, in Taku Inlet for use at Juneau, or at some of the numerous canneries is quite within the range of possibilities, though not as profitable as in the days before artificial ice was made.

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[5] Tarr, R. S., and Martin, L.: *Annals Assoc. Amer. Geographers*, Vol. 2, 1912, pp. 25-40.

[6] Dall, W. H.: Alaska and Its Resources, Boston, 1870, p. 252.

In connection with the halibut and salmon fisheries of southeastern Alaska, the fish are packed in iceberg ice from the tidal glaciers[7] near Petersburg and Wrangell, and delivered fresh in Seattle, nearly 800 miles distant. It is said that in some cases they are even shipped to the markets of eastern United States still packed in this glacial ice from Alaska.

Sources of Water Supply for Placer Mining. If large glaciers were still present in the mountains of Seward Peninsula or in parts of the Yukon Valley, where the regions near Rampart, Circle, Iditarod, Ruby, Nome, Eagle, Fairbanks, and Dawson suffer from lack of permanent water supply for placer mining, it would be a great advantage to the miners of these rich camps. Many of the expensive reservoirs, ditches, and flumes would be unnecessary if glaciers were present to keep the streams full during the summer. Some of the gold fields of other parts of Alaska, where the streams are fed by present day glaciers, as in parts of the Copper River valley, the region south of Mt. McKinley, and parts of southeastern Alaska, have had a great advantage in this respect.

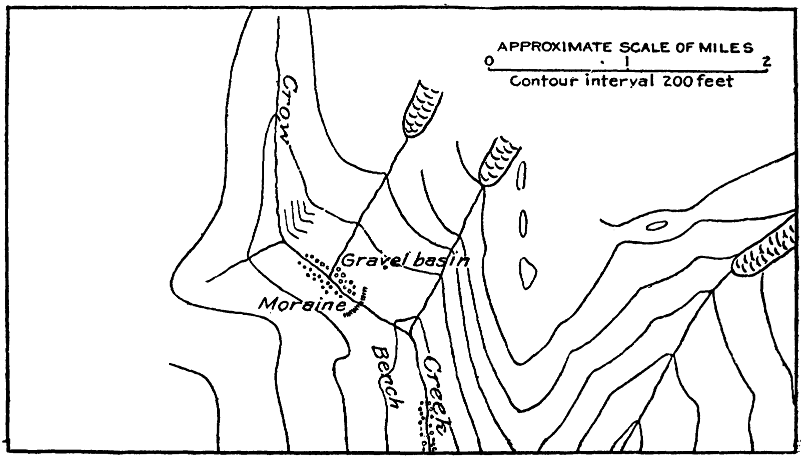

FIG. 8—Morainic dam in valley of Kenai Peninsula, above which auriferous gravels have accumulated in a small basin. (After F. H. Moffit.)

Relation to Placer Gold Deposits. The relation of glaciers to placer gold deposits has been indirect but important. Near Juneau, for example, Spencer has stated[8] that glacial sculpturing of the bed rock resulted in the accumulation of gravels in certain basins and, in these, placer gold deposits are found. He also shows that placer deposits have accumulated upstream from avalanches. The latter are perhaps due to oversteepening of valley walls by glacial erosion.

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[7] Moser, Jefferson F., *Bull. U. S. Fish Commission*, Vol. XXI, 1902, p. 309.

[8] Spencer, A. C.: The Juneau Gold Belt, *U. S. Geol. Survey Bull. 287*, 1906, pp. 78–79, 84.

Near Turnagain Arm, to take an illustration of a different sort, Moffit has shown[9] that the recessional moraine of a glacier has served as a dam (Fig. 8), above which gravels containing placer gold have accumulated. The glacial relationships of placer gold deposits in bench gravels and creek gravels in Alaska have not been sufficiently studied to be well established. In the rich deposits of the Seward Peninsula, the Fairbanks district, and the Alaskan extension of the Klondike, normal stream deposition without glacial stream supply has doubtless resulted in the deposition and concentration of part of the gold-bearing gravels. In many other areas it is glacial outwash that contains the gold. Beach placers, as at Nome and elsewhere, have few if any glacial relationships, but in some parts of Alaska it is possible that the especially high and persistent iceberg waves have resulted in greater concentration of gold in beach gravels, as upon Khantaak Island and Logan Beach when Malaspina and Hubbard Glaciers both ended in outer Yakutat Bay and caused continual iceberg waves in connection with the incessant discharge of icebergs from their fronts.

Obstacles to Mining. In some parts of Alaska the glaciers promise to be obstacles to mining. This is true now only to a slight extent, but may be more of an obstacle as more mines are developed and as the extension of mineral deposits becomes better known. In the Controller Bay coal field, for example, the formation containing the seams of anthracite and bituminous coal extends out beneath the Slope Glacier, under which mining may be impossible at the rather remote period when the large coal-bearing areas are worked out. The same applies to parts of the borders of Martin River Glacier and Bering Glacier (Fig. 12) in the same field. Malaspina Glacier doubtless covers large areas of coal-bearing rocks between the small coal seams on the west side of Yakutat Bay and the thicker seams in the Karr Hills southwest of Mt. St. Elias. Glaciers and glacial streams also complicate transportation and shipping of coal and ores.

The valuable copper deposits in the Wrangell Mountains, to which the railroad from Cordova has been built, are at the east border of the great Kennicott Glacier (Fig. 12), beneath which the enriched zone perhaps extends.

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[9] Moffit, F. H.: Gold Fields of Turnagain Arm Region, *U. S. Geol. Survey Bull. 277*, 1906, pp. 41-42.

Placer gold deposits extend up to the very edges of glaciers, and though there is no known deposit beneath a glacier, a sudden two-mile advance, like that of Hidden Glacier about 1907, would completely bury some gold-bearing gravels now accessible to mining.

Controls of Plant and Animal Life. The minor controls of plant and animal life by glaciers deserve brief mention. Ice-covered areas are, of course, barren. Near the glaciers there is the greatest contrast of vegetation cover, for example between Prince William Sound, where mature forests grow up to the very glacier margins, and the Yakutat Bay region, parts of which have a broad barren zone across which annual plants, willows, alders, cottonwoods, and spruces and other conifers are rapidly following the retreat of the glaciers. Other parts of the same region nearer the sea have trees up to and upon the margins of the glaciers. These vegetation-covers upon the ice are in an unstable position, being easily destroyed by slumping of the ablation moraine soil in which they grow, as the glaciers gradually melt, or destroyed completely during a period of advance, as in the case of the forest on Malaspina, Lucia, Atrevida, and Galiano Glaciers in Yakutat Bay in 1905-6. Forests upon outwash gravel fans in front of glaciers may be mown down by glacial advance or uprooted or buried by the shifting of aggrading glacial streams issuing from the retreating ice fronts, as at Columbia Glacier in Prince William Sound in 1909-11, and in other parts of the territory. Different glacial topographies, soils, and stages of drainage also cause infinite variations of forest, prairie, marsh, and other vegetation covers, as upon the Yakutat Foreland. Animals show similar relationships. There are no bears, wolves, or foxes between the impassably crevassed Hubbard and Nunatak Glaciers in Yakutat Bay, and here ptarmigan are very abundant, and sea gulls nest on the ground instead of seeking inaccessible cliffs. There are almost no deer between Cross Sound and Prince William Sound, where glaciers form a barrier, though deer are abundant to the southeast and caribou to the northwest. Mountain sheep and goats, however, live in most of these mountains. Salmon enter all of the clear streams in great numbers, but avoid most of the swifter and dirtier glacial streams, especially if they head in the glaciers instead of flowing from lakes. Salmon do run, however, in some of the glacial streams which have clear-water tributaries, as in the Copper River. No doubt many other relationships of this kind in connection with the plant and animal life will be discovered when special studies are made.

Modification of Climate. To what extent glaciers modify the climate of Alaska cannot yet be determined. The popular misconception that Alaska is bleak and frigid because it has great glaciers should be corrected. A summer, even among the mountains and glaciers, is not unlike a summer in the northern United States near Lake Superior or in parts of New England. Up among the snowfields, however, the glacial influence is naturally potent.

There are local, temporary modifications of climate, for example where down-valley winds from cold glaciers and snowfields cause chilly weather in lower main valleys and perhaps lead to fog and rain. Along the Pacific Coast, however, there are more warm sunny days up among the glaciers, as in Russell Fiord, than on the coast at the base of the mountains. On the whole it is probable that the climate of Alaska, with its existing glaciers, is not greatly unlike what it would be if there were no snow and ice fields, but if the same topography and wind systems were maintained. The influence of the glaciers seems to be distinctly minor, affecting the region in their immediate neighborhood, but extending their influence to no great distance. The Alaskan climate is determined by general causes of topography, latitude, wind direction, and proximity of water, and only locally and in minor degree by glacial conditions. The glaciers are a result of the climatic conditions, not in a notable degree the cause of them.

Cause of Unnavigable Streams. Glaciers give rise to streams that, though of good volume, are likely to be unnavigable because of swiftness and shifting courses, with shallowness and sand bars resulting from the heavy burden of sediment. On the other hand, during the summer months, their melting supplies steady volume to some streams that would not otherwise be navigable.

Where glaciers project into stream valleys the rivers may only be deflected slightly, as in the Stikine River opposite the Great Glacier and in the Copper River opposite Allen Glacier (Fig. 5), where, in each instance, steamer navigation is possible. Greater deflection results in impassable rapids, as where the Alsek Glacier gives rise to the lower rapids of the Alsek River. These rapids are not so swift and steep as is the Copper River, where Childs and Miles Glaciers force it into rapids (Fig. 5), the Abercrombie Rapids especially being entirely impassable for any boats but canoes, and then only at the greatest risk. The lower Copper and Alsek

Rivers, however, are unnavigable except by small boats because of the enormous deposition of glacial sediment upon their deltas.

Navigability has also been interfered with by glacial diversion by ice tongues that have now melted away. Along the historic route from Skagway to the Klondike gold district are the Whitehorse Rapids, in running which so many prospectors lost boats, provisions, and outfits. McConnell has stated[10] that these rapids are due to post-glacial cutting following the diversion of Lewes River by the more extended glaciers. Alaska has many illustrations of this phenomenon, where existing or former glaciers are directly responsible for unnavigability of streams.

As a result of the formation of hanging valleys, out of which streams descend in cascades and waterfalls and the production of waterfalls and rapids by glacial diversions and other forms of glacial interference with drainage, there has arisen a series of unutilized waterpowers of incalculable future value for generating electricity for motive power, lighting, hydraulic mining, running machinery at mines, canneries, etc., and long distance transmission for all sorts of uses in connection with the development of the great resources of Alaska.

Making Lakes. Lakes due to glacial erosion and deposition are abundant throughout Alaska. There are many long, narrow bodies of water, or finger lakes, most of them apparently due especially to glacial erosion, for example, Lakes Kenai, Klutena, Kluane, Sekulmun, Aishihik, Kusana, Lebarge, Marsh, Bennett, Tagish, Taku Arm, and many others. There are broader, irregular lakes, apparently dammed by glacial moraine accumulations, such as Lakes Iliamna, Clark, Tustumena, Skilak, and perhaps Kukaklek, Naknek, Becharof and the Ugashik Lakes. Bering Lake (Fig. 12) seems to be the head of Controller Bay cut off by the enormous glacial deposition by the streams from the west side of Bering Glacier. There are innumerable small glacial lakes along the margins of existing glaciers. There are great numbers of other small lakes due to erosion of minor rock basins by glaciers or to irregularities in the glacial drift.

Making Fiords. The fiords of the Inside Passage in southeastern Alaska, such as Lynn Canal, Chatham Strait, Stephens Passage, Behm and Portland Canals, and many others, and fiords like Glacier, Lituya, and Yakutat Bays and the branches of Prince William Sound are so obviously the result of former extension of the Alaskan glaciers that the explanation of their origin does not need amplification here. The straightness, as in the 90 miles of Lynn Canal, the depth, often over 1,000 feet, the general U-shape, the oversteepened lower slopes, the hanging of many tributary valleys above the main fiords, the resulting abundance of beautiful waterfalls, all these are now generally conceded to be the result of glacial erosion.[11] Gannett has computed[12] that more than 200 cubic miles of rock were eroded from Lynn Canal alone. This is a submerged coast but not necessarily a drowned coast, Gilbert having shown[13] that glaciers may have eroded the existing fiords without a change of sea level. Post-glacial sinking seems possible, but is not proved absolutely. Some of the finest scenery in the world has been produced, and it particularly emphasizes the relationship of glaciation to life, in connection with the navigability of these protected inner arms of the sea and the possibility of viewing this fiord scenery from the deck of a steamer.

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[10] McConnell, R. G.: Report on the Whitehorse Copper Belt, p. 4. Geol. Survey of Canada, 1908.

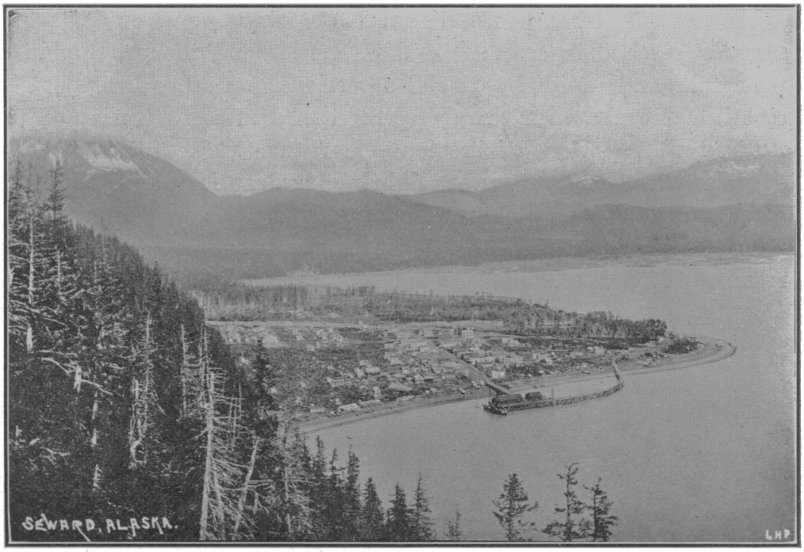

Fig. 9—The city of Seward on the delta of a glacial stream in the ice-sculptured fiord called Resurrection Bay.

There are certain detrimental features of this glacial erosion also. Islands have been so eroded that they no longer rise above sea level and, therefore, form dangerous reefs, a distinct menace to navigation in the partly uncharted and unlighted condition of this coast. The alternations of the maze of wide and narrow channels, with irregular tides sweeping in from various directions through the straits and fiords, causes very high and very swift tides in some places, adding to the hazard of navigation. Floating icebergs from the existing tidal glaciers also constitute a danger to ships traversing these waters. The toll paid to these dangers is already great, and one sees the evidence of it here and there along the Inside Passage where the wrecks of former days are still visible.

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[11] Tarr, R. S.: Glacial Erosion in Alaska, *Pop. Sci. Monthly*, Vol. 70, 1907, pp. 99–110.

[12] Gannett, Henry. *Nat. Geog. Mag.*, Vol. 12, 1901, p. 181.

[13] Gilbert, G. K. Harriman Alaska Expedition, Vol. III, 1904, pp. 210–218.

Town Sites. With the superabundance of harbors the sites of coast towns may or may not be related to glacial conditions. Sitka, Ketchikan, and Kodiak are on glaciated lowlands; Juneau and Skagway are each on the side of a glacially-shaped fiord; Cordova and Seward (Fig. 9) are located on good harbors where glaciation has modified the topography, glacial erosion perhaps increasing the depth of water so that steamships can come in close to shore. In all these towns the glacial influence is minor and cannot be said to have been the only determining influence in their location. A slight advance of Bear Glacier on Resurrection Bay near Seward, or of Shoup Glacier near Valdez would damage these harbors immeasurably, if indeed it did not stop steamer traffic completely.

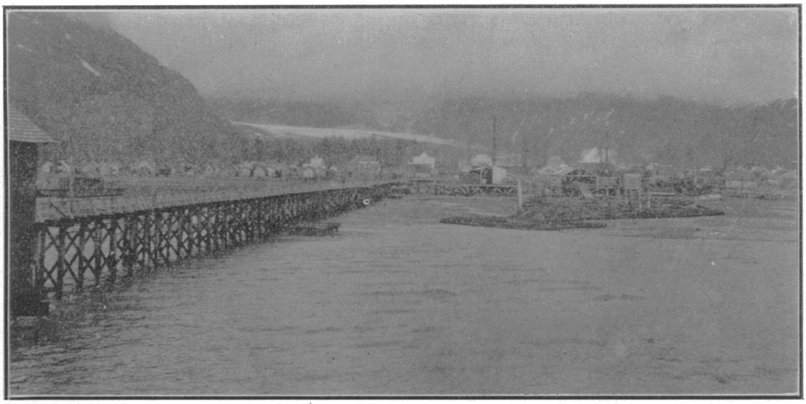


Fig. 10—One of the long piers at Valdez, made necessary by the deposits of glacial streams.

Shallow water from deposition by glacier-fed streams makes necessary the long piers at Skagway and Valdez (Fig. 10). Katalla (Fig. 12) has a town site located where it is because a landing place was needed close to the great Controller Bay coal fields, but to be of value it must be protected by an expensive breakwater. Glacial streams from the Bering Glacier have so shallowed Controller Bay that a good harbor here is lacking, though if permanent deep channels exist a fair town site may be situated later near Okalee Spit in the eastern part of Controller Bay.

Valdez is on a glacial outwash gravel plain. The town was founded because of the former travel across the glacier and, since this ceased, has been maintained because of the trail and road across the mountains behind and, before the building of the Copper River and Northwestern Railroad, because of the glacial barrier in the lower Copper River. Only recently gold has been found at Valdez. Glacial streams sometimes threaten the town, as when streets were flooded and houses swept away in 1905 (Fig. 11). Valdez, on a deep, glacially eroded fiord, and one of the most beautifully situated towns in Alaska from the point of view of scenery, has one of the poorest sites as far as permanency is concerned. This town site perhaps shows more direct relationships to existing glaciers than any other.

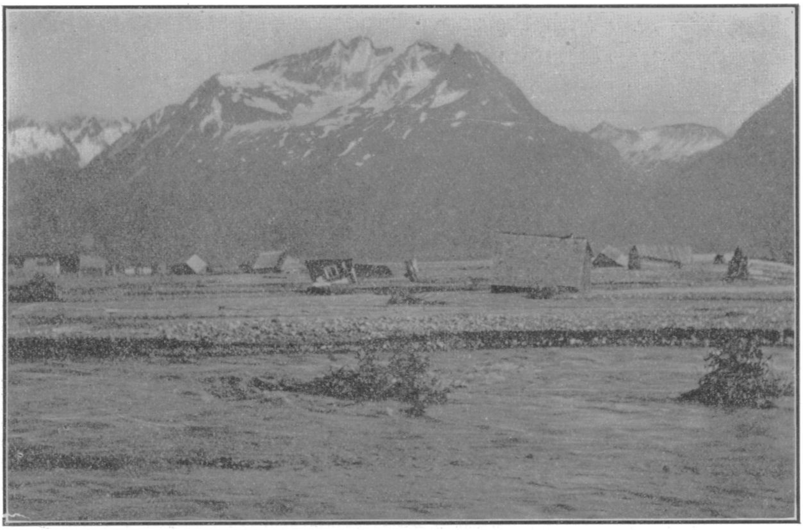
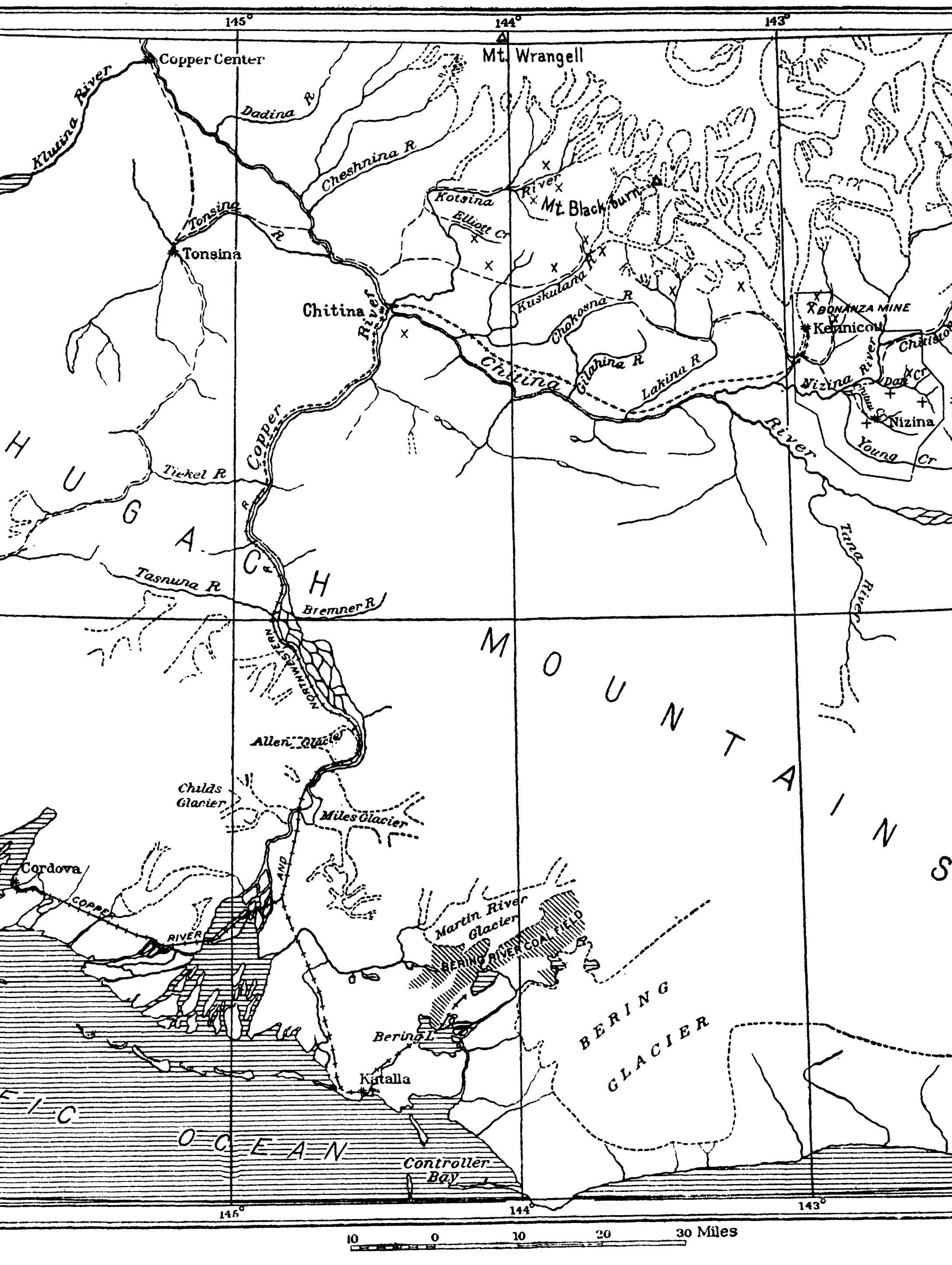


Fig. 11—Cabins in the city of Valdez overthrown by the shifting of a glacial stream in 1905.



-Map showing (a) the relationship of the Bering River coal field near Controller Bay to the Bering and Martin River Glaciers, relationship of the Copper River delta to the location of the town of Cordova, (c) of the City of Valdez to the Valdez Glacier and (d) the relationship of the Copper River and Northwestern Railroad to the Miles, Childs, and Allen Glaciers and the ice-tongues near the Bonanza copper mine at Kennicott. (After U. S. Geological Survey.) Scale 1:1,250,000.